Total Cost of Ownership – Technologies for Optimized Transmitter Systems

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IBC 2015

Featuring GatesAir’s
Rich Redmond
Chief Product Officer
Total Cost of Ownership - Technologies for Optimized Transmitter Systems

IBC 2015
Issues Broadcasters and Operators are Facing

Rising Cost of Energy

- World electricity prices have increased by an average of 6.6% per year for the past 5 years
- Projected to continue to rise throughout the world - 60% increase by 2030

Electricity Prices Hit all Time High

![Graph: Electricity Prices Hit all Time High]

Carbon Taxes

- Some countries are imposing taxes based on energy usage, example Australia from 2012-14:

<table>
<thead>
<tr>
<th>Financial Year</th>
<th>Price* (USD $)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012–13</td>
<td>23.00</td>
</tr>
<tr>
<td>2014</td>
<td>24.15</td>
</tr>
</tbody>
</table>

Source: Clean Energy Regulator - per tonne of emitted CO₂
Total Cost of Ownership

- **Total Cost of Ownership - General Definition**

  Total Cost of Ownership is the total cost of acquisition and operating costs over the asset life cycle. A TCO analysis can be used to gauge the viability of any capital investment.
Factors Affecting TCO

- When purchasing, or replacing a transmitter, Total Cost of Ownership is more important than just the purchase price alone.
- Some of the items that must be considered:
  - Equipment acquisition cost (inc. taxes/duties/shipping, etc.)
  - Financing/Loan/Payment Terms (if applicable)
  - Building space requirements (own, lease, purchase)
  - Shipping to site, Installation and commissioning costs
  - Operational cost of the equipment, including:
    - AC power costs
    - Personnel training
    - Routine maintenance costs / site visits
    - Repair costs
    - Upgrades
    - Warranty and other factors
TCO versus Efficiency

TCO is what is really important to a transmission operator:
- It’s the total cost to own and operate the transmitter system over time
- Includes initial equipment cost and delivery
- Includes the installation/commissioning cost
- Includes routine and unscheduled maintenance costs
- Repair/replacement and other operational costs

AC power consumed by the transmitter is important
- However, other factors also affect the system efficiency:
  - AC transformers and voltage regulators
  - Heat load to the room (HVAC costs)
  - RF system losses (often significant)
  - RF feeder losses
    - ex: Ch30, 2,000ft, 6-1/8” rigid line, energy loss = 38%
    - Non-optimal antenna pattern (throwing RF energy away)
### Effect of Power Supply Efficiency on Overall System Efficiency

#### Distribution of Power Usage with Older Technology Power Supplies
- **Power to PA's**: 77% of Total
- **Distribution**:
  - Power Supply Loss: 12%
  - Drivers: 4%
  - Exciter: 1%
  - Control: 1%

#### Distribution of Power Usage with High Efficiency Power Supplies
- **Power to PA's**: 83% of Total
- **Distribution**:
  - Power Supply Loss: 6%
  - Drivers: 4%
  - Exciter: 1%
  - Control: 1%

<table>
<thead>
<tr>
<th></th>
<th>Tx with older PS</th>
<th>Tx with new High Eff. PS</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF Power Output (kW)</td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Power Amplifier Efficiency</td>
<td>45%</td>
<td>45%</td>
</tr>
<tr>
<td>DC Power to PA's</td>
<td>11.11</td>
<td>11.11</td>
</tr>
<tr>
<td>Power Supply Efficiency</td>
<td>86%</td>
<td>96%</td>
</tr>
<tr>
<td>AC Power to PA's</td>
<td>12.92</td>
<td>11.57</td>
</tr>
<tr>
<td>Power Supply Loss</td>
<td>1.81</td>
<td>0.46</td>
</tr>
<tr>
<td>Drivers</td>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>Exciter</td>
<td>0.14</td>
<td>0.14</td>
</tr>
<tr>
<td>Control</td>
<td>0.12</td>
<td>0.12</td>
</tr>
<tr>
<td>Cooling</td>
<td>0.75</td>
<td>0.75</td>
</tr>
<tr>
<td>Total AC Input (kW)</td>
<td>14.53</td>
<td>13.18</td>
</tr>
<tr>
<td>Overall Tx Efficiency</td>
<td>34%</td>
<td>38%</td>
</tr>
</tbody>
</table>
At GatesAir we are constantly updating designs to improve efficiency and lower TCO:

- Higher Efficiency RF Devices & PA Module design
- Higher Efficiency Power Supplies
- Optimized Energy Efficient Cooling Systems
- Broadband, future-proof designs
- Improved up-time and reduced maintenance costs
- Modular designs with Faster MTTR (Mean Time To Repair)
- Higher Power Density for reduced floor space
- User-friendly designs, easier to understand and operate
RF Device Technology

- New 50V LDMOS devices introduced that dramatically increase power density and efficiency
- Broadband high efficiency TV devices for VHF Band III and for UHF
- High Gain (> 15dB)
- Power 600W (CW) / 130 W TV average power
- Rugged
- Very High MTBF

BLF888D Features and benefits (from data sheet):
- High efficiency
- High power gain
- Excellent ruggedness (VSWR > 40 : 1 through all phases)
- Excellent thermal stability
- Integrated ESD protection
- One Doherty design covers the full bandwidth from 470 MHz to 860 MHz
- Internal input matching for ease of use
Wideband Efficiency Optimized UHF Pallets

- **Higher Efficiency Pallets:**
  - **Objective** - Meet or exceed *any* competitive system level efficiency
  - 6% to 10% System level Efficiency improvement
  - Up to 44% AC to RF system efficiency for COFDM
  - *Broadband version will still be available*

![Diagram of Pallet Efficiency with frequency bands]

<table>
<thead>
<tr>
<th>Pallet Model</th>
<th>Frequency Range</th>
<th>8 MHz Channels</th>
<th>6 MHz Channels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Band A</td>
<td>470 – 590</td>
<td>21 - 35</td>
<td>14 - 33</td>
</tr>
<tr>
<td>Band B</td>
<td>590 – 718</td>
<td>36 - 51</td>
<td>34 - 54</td>
</tr>
<tr>
<td>Band C</td>
<td>718 – 862</td>
<td>52 - 69</td>
<td>55 - 78</td>
</tr>
</tbody>
</table>
Power Supply Technology

- Improvements in Power density/weight
- Very high conversion efficiency
  - 96.3% versus 84% only 6 years ago
- With 48-50V DC requirement, can leverage the Telecomm industry:
  - Very high MTBF (900,000hrs)
  - High volume part
  - Widely available Worldwide
- Versatile
  - Use same part in FM and TV products

### Reliability (calculated)

<table>
<thead>
<tr>
<th>Reliability (calculated)</th>
<th>900,000</th>
<th>Hours</th>
</tr>
</thead>
</table>

At ambient of 25°C at full load per Telcordia SR-332, issue 2, Reliability Prediction for Electronic Equipment, Method I Case III.
Three Ways to Cool the Transmitter

1. Air-cooling using outside air

2. Air-cooling using inside air and Air-Conditioning

3. Liquid-cooling

~90% of heat goes outside via liquid

Outdoor Fan Unit

Outdoor A/C Unit

Minimal heat load to room

Small HVAC Unit

Cooling air

Warm exhaust air

Warm air

Cool air

Intake Fan

Exhaust Fan

Air Filter

For dust & pollen

Air Duct

Louvers

And insect shield

HVAC Unit

Pump

Back

Proprietary and confidential.
# Cooling Comparison

<table>
<thead>
<tr>
<th>Item</th>
<th>Air-Cooled (outside air)</th>
<th>Air-Cooled (HVAC)</th>
<th>Liquid Cooled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy cost</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Maintenance</td>
<td>Very High</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Installation cost</td>
<td>High</td>
<td>Medium</td>
<td>Medium/Low</td>
</tr>
<tr>
<td>Site visits</td>
<td>Frequent</td>
<td>Infrequent</td>
<td>Infrequent</td>
</tr>
<tr>
<td>Humidity control</td>
<td>None</td>
<td>Excellent</td>
<td>Excellent</td>
</tr>
<tr>
<td>Dust &amp; dirt</td>
<td>Filter dependent</td>
<td>Excellent</td>
<td>Excellent</td>
</tr>
<tr>
<td>Reliability</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium/Excellent</td>
</tr>
<tr>
<td><strong>TCO Rank</strong></td>
<td><strong>3</strong></td>
<td><strong>2</strong></td>
<td><strong>1</strong></td>
</tr>
</tbody>
</table>
Space Savings Trend (TV liquid-cooled Tx)

For consistency all transmitters shown are Harris/GatesAir

Power Density kW/m²

Atlas


ULX

ULXT

16.02

Next Gen Tx?

Create

Transport

Transmit Television

Transmit Radio
The GatesAir TCO Calculator

- TCO Calculator:
  - Calculates the total cost of ownership of a transmitter system
  - Compares TCO of a new GatesAir transmitter with your existing transmitter (GatesAir or another brand)
  - Adjust cost of AC power and other factors to match your scenario
  - Calculate total savings over time
  - Estimate break-even period
TCO – New vs. Previous Gen Tx

- Input New Tx Data (Maxiva ULXT)
  - Tx Model
  - Tx Max power level
  - Required power level
  - New Tx cost
  - Installation cost
  - Commissioning cost
  - Training cost
  - Electrical cost (look up table, or manual entry)
  - Currency/ex rate (manual entry)

- Based on some preset criteria, TCO is calculated

New GatesAir Transmitter TCO Analysis

<table>
<thead>
<tr>
<th>SYSTEM VARIABLES</th>
<th>entry cells in pink</th>
<th>OPEX &amp; TCO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmitter Model &amp; Costs:</td>
<td>Maxiva ULXT COFDM</td>
<td>Currency</td>
</tr>
<tr>
<td>Product Series</td>
<td>ULXT-10DV/T2/15</td>
<td>Exchange Rate</td>
</tr>
<tr>
<td>Model</td>
<td></td>
<td>Annual OPEX</td>
</tr>
<tr>
<td>Tx Maximum Output Power</td>
<td>5,500 W</td>
<td>First Year TCO</td>
</tr>
<tr>
<td>Required Output Power</td>
<td>5,000 W</td>
<td>Five Year TCO</td>
</tr>
<tr>
<td>Tx Purchase Price</td>
<td>120,000</td>
<td>Ten Year TCO</td>
</tr>
<tr>
<td>Installation</td>
<td>0</td>
<td>Fifteen Year TCO</td>
</tr>
<tr>
<td>Commissioning</td>
<td>0</td>
<td>Twenty Year TCO</td>
</tr>
<tr>
<td>Training</td>
<td>0</td>
<td>Total Cost</td>
</tr>
</tbody>
</table>

Energy Costs:
- Region: Eastern Europe
- Country/State: Czech Republic
- Electricity Price/KW-hr: 0.1650
- Price/KW-hr (override): 0.1800
- Tx System Efficiency: 37.0%
TCO – New vs. Previous Gen Tx

- Input Existing Tx Data
  - Tx Model
  - Tx Max power level
  - Required power level
  - Costs can be left as zero for existing tx
  - Electrical cost copied from new tx data
  - Currency/ex rate (manual entry)

- Based on some preset criteria, TCO is calculated

Older Technology
Transmitter TCO Analysis

**SYSTEM VARIABLES**

<table>
<thead>
<tr>
<th>Transmitter Model &amp; Costs:</th>
<th>OPEX &amp; TCO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product Series</td>
<td></td>
</tr>
<tr>
<td>Model</td>
<td></td>
</tr>
<tr>
<td>ULX-5500</td>
<td></td>
</tr>
<tr>
<td>Tx Maximum Output Power</td>
<td></td>
</tr>
<tr>
<td>5,850 W</td>
<td></td>
</tr>
<tr>
<td>Required Output Power</td>
<td></td>
</tr>
<tr>
<td>5,000 W</td>
<td></td>
</tr>
<tr>
<td>Purchase Price</td>
<td></td>
</tr>
<tr>
<td>110,000</td>
<td></td>
</tr>
<tr>
<td>Installation</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Commissioning</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Training</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Total Cost</td>
<td>110,000</td>
</tr>
</tbody>
</table>

**Energy Costs:**

<table>
<thead>
<tr>
<th>Region</th>
<th>Electricity Price/kW-hr¹</th>
<th>Price/kW-hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastern Europe</td>
<td>0.1650</td>
<td>0.1800</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>0.1650</td>
<td>0.1800</td>
</tr>
</tbody>
</table>

¹ Multiple sources used - 2010 data, GatesAir not responsible for accuracy.
### TCO – New vs. Previous Gen Tx

- GatesAir ULXT and ULX transmitters
- Side-by-side comparison
- New vs. previous generation solid DTV state tx
- $93k savings in first 5 years
- Over $300k savings over the life of the transmitter

<table>
<thead>
<tr>
<th>Transmitter Models:</th>
<th>ULXT-10DV/T2/IS</th>
<th>ULX-5500</th>
<th>Estimated Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product Series</td>
<td>Maxiva ULXT COFDM</td>
<td>Maxiva ULX COFDM</td>
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<tr>
<td>Model</td>
<td>ULXT-10DV/T2/IS</td>
<td>ULX-5500</td>
<td></td>
</tr>
<tr>
<td>Tx Maximum Output Power</td>
<td>5,500 W</td>
<td>5,850 W</td>
<td></td>
</tr>
<tr>
<td>Required Output Power</td>
<td>5,000 W</td>
<td>5,000 W</td>
<td></td>
</tr>
<tr>
<td>Purchase Price</td>
<td>120,000</td>
<td>110,000</td>
<td>-10,000</td>
</tr>
<tr>
<td>Installation</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Commissioning</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Training</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total Cost</td>
<td>120,000</td>
<td>110,000</td>
<td>-10,000</td>
</tr>
<tr>
<td>Energy Costs:</td>
<td>Eastern Europe Czech Republic</td>
<td>Eastern Europe Czech Republic</td>
<td></td>
</tr>
<tr>
<td>Region</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Country/State</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Price/kWh</td>
<td>$0.180</td>
<td>$0.180</td>
<td></td>
</tr>
<tr>
<td>Tx System Efficiency</td>
<td>37.0%</td>
<td>19.6%</td>
<td></td>
</tr>
<tr>
<td>OPEX:</td>
<td>ULXT-10DV/T2/IS</td>
<td>ULX-5500</td>
<td>Estimated Savings</td>
</tr>
<tr>
<td>Annual OPEX</td>
<td>27,186</td>
<td>47,882</td>
<td></td>
</tr>
<tr>
<td>Year 1 TCO</td>
<td>153,686</td>
<td>164,382</td>
<td></td>
</tr>
<tr>
<td>Year 5 TCO</td>
<td>252,432</td>
<td>325,509</td>
<td></td>
</tr>
<tr>
<td>Year 10 TCO</td>
<td>358,364</td>
<td>595,318</td>
<td></td>
</tr>
<tr>
<td>Year 15 TCO</td>
<td>554,296</td>
<td>834,725</td>
<td></td>
</tr>
<tr>
<td>Year 20 TCO</td>
<td>670,228</td>
<td>1,074,135</td>
<td></td>
</tr>
<tr>
<td>Breakeven Period</td>
<td></td>
<td>1.0 Years</td>
<td></td>
</tr>
</tbody>
</table>

*Proprietary and confidential.*
TCO – New vs. Previous Gen Tx

- Graphical representation
- GatesAir ULXT and ULX transmitters
- New TX Blue
- Old Tx Red
- Savings over time Green
  - Typically, transmitter pays for itself in 5 to 10 years
  - Less heat load to building due to higher efficiency
NEW FLX Liquid Cooled FM Transmitter

- **FLX10K**
  - 12 kW Analog at 72% AC-RF Efficiency
  - 9.7 kW Analog, FM+HD @ -14dBc – 60% AC-RF Efficiency
  - 7.7 kW Analog, FM+HD @ -10dBc – 55% AC-RF Efficiency
- **Power Block Scalable 5kW - 80kw**

Available in Digital-Ready Analog Or Fully Digital
Flexiva™ FLXT Liquid-Cooled FM Transmitters

**FLX10K 16RU Cabinet**

- 12 kW average power
- 17kW peak power
- 7 - 50 Volt, 2.75 kW power supplies
  - 96% AC-DC Efficiency
- 14 - **New** 970 Watt PA pallets
- 7 - 1940 Watt PA modules
  - 82% DC-RF PA efficiency
- Dual Exciter and IPA – failover switching
Flexiva™ FLXT Liquid-Cooled FM Transmitters

- 88% overall heat dissipation to liquid transfer efficiency
- Internal or external redundant pump modules
- Two 10kW transmitters with dual exciters, in a single rack
- 20kW with dual exciters in a single rack
- 40kW in four racks

= Lowest Total Cost of Ownership!
## Transmitter TCO Comparison (GatesAir / GatesAir)

### Transmitter Models:
- **FLX T 10K @ -10**
- **FAX 10K @ -10**

### Product Series
- **FLXT**
- **Flexiva FM HD Transmitter**

### Estimated Savings

<table>
<thead>
<tr>
<th></th>
<th>FLX T 10K @ -10</th>
<th>FAX 10K @ -10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tx Maximum Output Power</td>
<td>7,700 W</td>
<td>7,700 W</td>
</tr>
<tr>
<td>Required Output Power</td>
<td>7,600 W</td>
<td>7,600 W</td>
</tr>
<tr>
<td>Purchase Price</td>
<td>$85,000.00</td>
<td>$85,000.00</td>
</tr>
<tr>
<td>Installation</td>
<td>$23,093</td>
<td>$23,093</td>
</tr>
<tr>
<td>Commissioning</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Training</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total Cost</td>
<td>$108,093</td>
<td>$108,093</td>
</tr>
</tbody>
</table>

### Energy Costs:
- **Region**: USA, Florida
- **Price/kWh**: $0.120, $0.120
- **Tx System Efficiency**: 53.7%, 51.3%

### OPEX:
- **Annual OPEX**: FLX T 10K @ -10 ($18,679), FAX 10K @ -10 ($24,630)
- **Year 1 TCO**: FLX T 10K @ -10 ($148,571), FAX 10K @ -10 ($137,223)
- **Year 5 TCO**: FLX T 10K @ -10 ($223,289), FAX 10K @ -10 ($235,745)
- **Year 15 TCO**: FLX T 10K @ -10 ($316,687), FAX 10K @ -10 ($358,897)
- **Year 20 TCO**: FLX T 10K @ -10 ($410,084), FAX 10K @ -10 ($482,048)

### Breakeven Period
- FLX T 10K @ -10: 3.0 Years

### Notes & Assumptions:
- Operating output power must be less than or equal to the max. Tx power is pre-filtered.
- No real estate purchase or rental costs are included.
- Annual Tx maintenance of $2,400 (unless edited in cells V10, V11)
- HVAC acquisition cost of $1,150/ton, installation cost of $2,500 (unless edited in cell V7)
- Tx heat load to room is cooled by HVAC system. Default SEER = 12 (unless edited in cells V6, V10)
Summary – Things to Consider

- Broadband versus Wideband TV Transmitter
- Potential utility company rebates?
- Obsolescence and spare parts availability?
- High-voltage vs. Low-voltage (safety)
- Tx complexity and serviceability
- Modularity and On-air reliability
- Size, weight and ease of replacing modules
- Service & support from manufacturer